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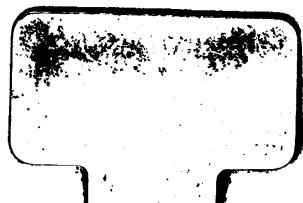
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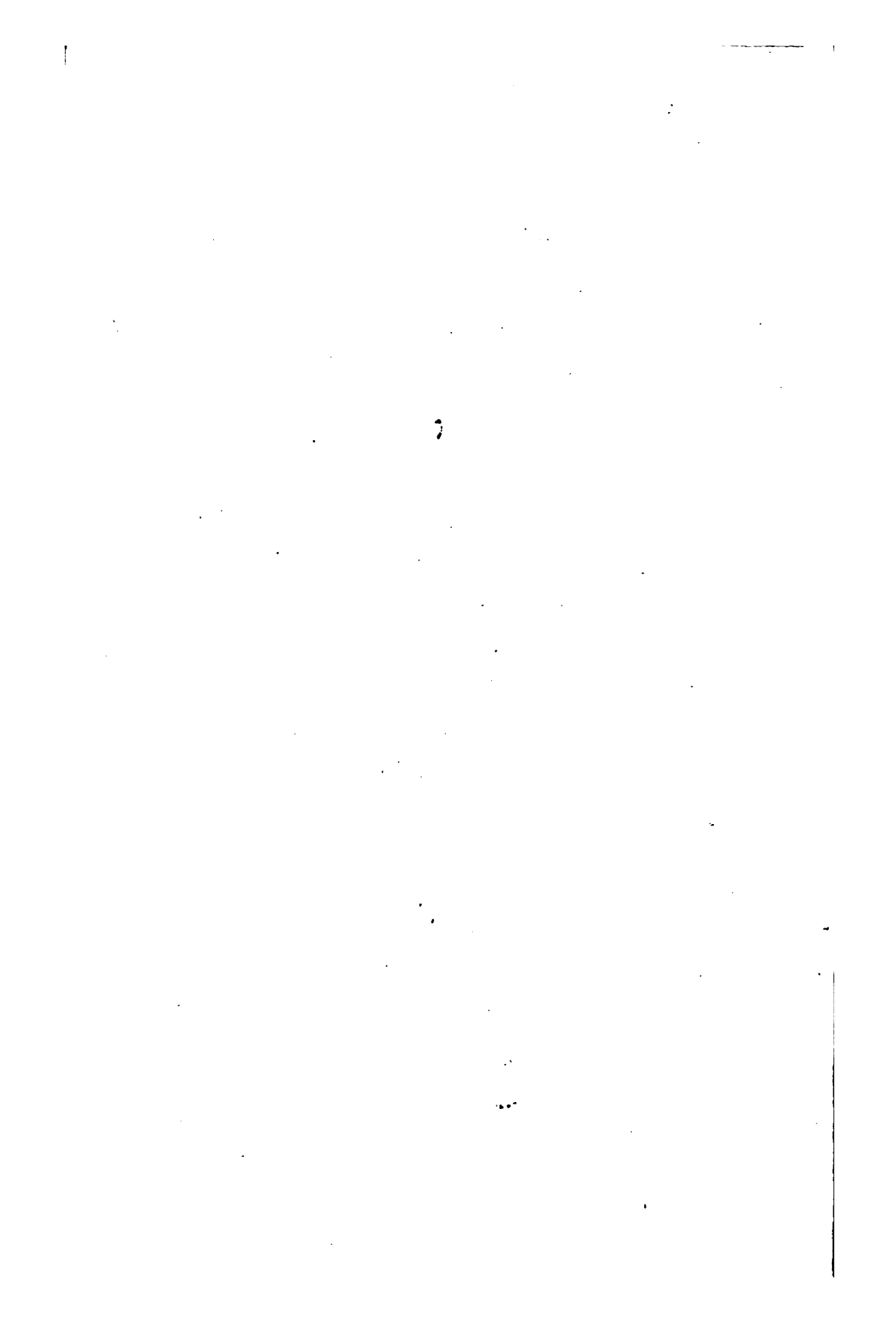
ANALYTICAL TABLES
FOR STUDENTS OF
PRACTICAL CHEMISTRY

J. CAMPBELL BROWN
D. SC. (LOND.) F. C. S.

193. e.

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ANALYTICAL TABLES,

FOR STUDENTS OF

PRACTICAL CHEMISTRY:



BY

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SEVERAL teachers, as well as students, of Practical Chemistry have asked me to print the tables by the aid of which I am in the habit of teaching candidates for degrees and certificates in science and in medicine, as well as technical students.

I have, therefore, been induced to publish the following part of the series, in the hope that it may be useful to those who are in the habit of using either manuscript or lithographed tables, prepared year by year. They are not intended to supersede *viva voce* instruction, but to be used as notes by which to follow and recall to mind the demonstrations of the teacher.

Although these tables are arranged for the examination of complex substances, they may be conveniently employed for the detection of simple substances, by omitting all those details which refer to the separation of one substance from another.

J. C. B.

TABLE FOR ANALYSIS OF GASES.

Note the colour and odour of the Gases.

Separate the Gases into two groups by a solution of Potash.

I. Gases not absorbed by a solution of Potash.

Test the Gases by means of a lighted taper.

Not inflammable, but support combustion :

1. OXYGEN.
2. NITROUS OXIDE.

Not inflammable, but extinguish flame :

3. NITRIC OXIDE.
4. NITROGEN.

Inflammable.—Observe the colour of the flame, and test the products of combustion with lime water.

Products of combustion render lime water turbid :

5. CARBONOUS OXIDE; flame blue.
6. MARSH GAS; flame pale yellow.
7. OLEFIANT GAS; flame bright yellow.

Products of combustion do not render lime water turbid :

8. HYDROGEN; flame colourless.
9. HYDRIDE OF PHOSPHORUS; flame very bright, producing thick white fumes of P_2O_5 .
10. HYDRIDE OF ARSENIC; flame livid, odour of garlic.
11. HYDRIDE OF ANTIMONY; flame bluish-white, producing white fumes.

If the Gases explode on the application of a lighted taper, a mixture of Oxygen with combustible Gas is indicated.

1. OXYGEN is absorbed by Pyrogallie Acid and solution of Potash; producing a black liquid.
2. NITROUS OXIDE (N_2O) when exploded with Hydrogen, or heated with Potassium, leaves a residue of Nitrogen, whose volume is equal to that of the Nitrous Oxide employed.

3. NITRIC OXIDE ($N_2 O_3$) is transformed into red fumes of Nitric Peroxide ($N_2 O_4$) when mixed with air or Oxygen.
4. NITROGEN is characterised by its neutrality to all tests.
5. CARBONOUS OXIDE (C O) is absorbed by an ammoniacal solution of cuprous Chloride.
6. MARSH GAS differs from Olefiant Gas in not being absorbed by Chlorine, Bromine, or fuming Sulphuric Acid.
7. OLEFIANT GAS (Ethylene) forms liquid compounds with Chlorine and Bromine, and is absorbed by fuming Sulphuric Acid.
8. HYDROGEN is extremely light and diffusible, and when mixed with Chlorine explodes on the application of a lighted taper.
9. HYDRIDE OF PHOSPHORUS is generally spontaneously inflammable in air.
10. HYDRIDE OF ARSENIC, and 11., HYDRIDE OF ANTIMONY, may be distinguished by introducing a cold white porcelain plate or dish into their flame, when a metallic deposit is obtained. The Arsenic deposit is dissolved both by Nitric Acid and by Sodium Hypochlorite. The Antimony stain is rendered white by Nitric Acid, and is unchanged by Sodium Hypochlorite.

II. Gases absorbed by a solution of Potash. These Gases can generally be distinguished in the free state as well as after absorption by Potash.

Not inflammable :

1. AMMONIA ($N H_3$) can be recognised by its odour, and by its alkaline reaction with reddened litmus paper. It is very soluble in water.
2. SULPHUROUS OXIDE ($S O_2$) Has an odour of burning matches, and is soluble in water. It reduces an acid solution of Potassium Chromate to green.
3. CARBONIC DIOXIDE ($C O_2$) renders lime water turbid.
4. CHLORINE has a peculiar suffocating odour, and olive-green colour. It bleaches vegetable colours, and renders a solution of Potassium Iodide in starch-paste blue.
5. HYDROCHLORIC ACID fumes in air, has pungent odour, is very soluble in water, and forms a white curdy precipitate with Silver Nitrate.
6. HYDROFLUORIC ACID etches glass.
7. HYDROFLUO-SILICIC is decomposed by water, producing a deposit of gelatinous Silica.

Inflammable :

8. HYDROSULPHURIC ACID has an odour of rotten eggs, and blackens paper moistened with solution of Lead Acetate.
9. HYDROCYANIC ACID burns with a bluish flame. It is very soluble in water, and may be detected by the tests given on page 18.

PRELIMINARY EXAMINATION

FOR SIMPLE SALTS AND MIXTURES.

If the substance is a liquid, examine it by blue and red litmus papers; evaporate a portion to dryness and treat the residue as under. If the substance is solid, reduce it to fine powder, noticing its physical characters.

1. Heat a small portion of the finely pulverized substance in a glass tube.

If the substance does not change, organic matter, Hydrates, salts containing water of crystallization, fusible and volatile substances are all absent.

The substance chars. Presence of organic matter. Acetone is given off—from decomposition of ACETATES. A carbonate is left, effervescing with acids—from ORGANIC ACIDS united with a mineral base.

The substance changes colour—

To yellow while hot,
white on cooling . . . Presence of OXIDE OF ZINC, Zn O .

To yellowish-brown, becoming dirty yellow
on cooling " OXIDE OF TIN, Sn O_2 .

To reddish-brown, and
yellow when cold . . . " OXIDE OF LEAD, Pb O .

To orange-red, dull yellow when cold . . . " OXIDE OF BISMUTH, $\text{Bi}_2 \text{O}_3$.

The substance fuses and swells up, giving off steam. Salts having water of crystallization, e.g., Alum, Borax, or Hydrates.

Test the reaction of the fluid condensed in the tube.

If alkaline, AMMONIA, and if acid, VOLATILE ACIDS are present.

The substance gives off gases or fumes—

Oxygen (supports combustion) PEROXIDES, NITRATES, CHLORATES, &c.

Sulphurous Gas, S O_2 (odour) from SULPHITES, and HYPOSULPHITES.

Nitric Peroxide, $\text{N}_2 \text{O}_4$ (reddish-brown vapours) from the decomposition of NITRATES.

Carbonic Gas, C O_2 (precipitates lime water) from CARBONATES.

Carbonous Oxide, C O (burns with blue flame) from OXALATES, and FORMATES.

Cyanogen, C N (odour, and peach-blossom coloured flame) from CYANOGEN compounds.

Carbon Disulphide, CS_2 , from SULPHOCYANATES.

Hydrosulphuric Acid, H_2S (odour, and blackens lead paper) from moist SULPHIDES, SULPHITES, and HYPOSULPHITES.

Ammonia, NH_3 (odour, and alkaline to test paper) from AMMONIUM SALTS and some CYANOGEN compounds.

The substance sublimes into the cold part of the tube.

In yellow drops of Sulphur, . . . From SULPHIDES and free SULPHUR, and HYPOSULPHITES.

Yellow Crystals MERCURIC IODIDE, or ARSENIOUS SULPHIDE.

White sublimate which evolves

Ammonia when heated with

Lime or Potash AMMONIUM SALTS.

Black Sublimate, violet fumes IODINE.

Sublimate, when heated with

dry Sodium Carbonate and

Potassium Cyanide in a bulb

tube, gives metallic mirror

and globules MERCURY (Hg) compounds.

or black shining mirror ARSENIC (As) compounds.

II. Heat a portion of the substance on charcoal in the blow-pipe flame.

It decrepitates Many Salts.

It deflagrates NITRATES, CHLORATES.

It fuses and is absorbed ALKALINE SALTS.

The residue is white and lu-

minous ALKALINE EARTHS, ALUMINA, ZINC OXIDE, or SILICA.

Moisten the infusible residue with a drop of Cobalt Nitrate, and heat again in blow-pipe flame —

A blue mass remains . . . ALUMINA, SILICATES, or some PHOSPHATES.

A pink mass " . . . MAGNESIA.

A green mass " . . . ZINC OXIDE.

The residue is coloured. Heat a small portion in a clear borax bead on platinum wire in the inner and outer blow-pipe flame.

Blue in the inner, blue in the outer flame	COBALT, Co.
Red " blue " "	COPPER, Cu.
Greyish-red " " "	NICKEL, Ni.
Colourless " Amethyst-red "	MANGANESE, Mn.
Green " Bottle-red "	IRON, Fe.
Green " Green "	CHROMIUM, Cr.

The residue is metallic when the inner blow-pipe flame is used.

Brilliant, hard, and malleable	SILVER, Ag.
Yellow " "	GOLD, Au.
Red scales or globules	COPPER, Cu.
Soft and malleable	LEAD, Pb.
Brittle; no incrustation, or only a slight yellow deposit.	BISMUTH, Bi.
Brittle; gives white fumes and white incrustation	ANTIMONY, Sb.

The metal is reduced, but, being volatile, passes through the outer flame and yields an incrustation.

White, with garlic odour	ARSENIC, As.
Yellow while hot, white on cooling	ZINC, Zn.
Brown	CADMIUM, Cd.

TIN, Sn., requires the assistance of Potassium Cyanide to aid its reduction. The metal is bright and malleable. The slight incrustation is yellow when hot, white when cold.

III. Heat a small portion of the substance on a clean platinum wire, either in the inner blow-pipe flame, or in a colourless Bunsen flame.

The substance tinges the flame yellow . . .	SODIUM, Na.
" " " violet . . .	POTASSIUM, K.
" " " olive-green .	BARIUM, Ba.
" " " crimson . .	STRONTIUM, Sr, or LITHIUM, Li.
" " " red	CALCIUM, Ca.
" " " green mixed with blue .	COPPER, Cu.

IV. Heat with Hydrochloric Acid, H Cl, in a test tube.

Effervescence. The evolved gas renders lime-water turbid, CO_2 , from CARBONATES.

The Gas has odour of burning Sulphur, SO_2	from SULPHITES.
The same with separation of Sulphur	from HYPOSULPHITES.
The Gas has odour of rotten eggs, and blackens paper moistened with Lead Acetate, H_2S	from SULPHIDES.
Reddish-brown fumes, N_2O_3	from NITRITES,
Chlorine	from HYPOCHLORITES or BINOXIDES.
Euchlorine	from CHLORATES.
A jelly is formed; SILICA, from soluble SILICATES.	

Before proceeding to the systematic examination of a substance, a solution must be prepared. 1.—Dissolve in water and filter. 2.—Treat the residue, insoluble in water, with Hydrochloric Acid (H Cl), Nitric Acid (H NO_3), and Aqua Regia, successively. 3.—Any residue, insoluble in water and acids, must be dried, mixed with four times its weight of dry Alkaline Carbonates (K_2CO_3 , and Na_2CO_3), and fused in a crucible. Boil the fused mass with water, and filter; examine the filtrate for acids; dissolve the insoluble portion (which contains the bases, in the form of Carbonates,) in H Cl , and examine the solution separately.

If the substance is a *metal* or *alloy*, having observed its physical characters, reduce it to thin sheets or filings; then—

1. Heat a small portion with water and Acetic Acid; Hydrogen is evolved; presence of Na, K or Mg. Examine the solution by Table for group VI.
 2. Heat a portion in a glass tube, sealed at one end. A sublimate indicates Hg, As, or Cd.
 3. Dissolve in H NO_3 , and dilute with water.
 - (a.) The metal dissolves with evolution of red fumes. Presence of Ag, Hg, Pb, Bi, Cu, Cd, As, Fe, or Zn. Examine the solution in the usual way.
 - (b.) Red fumes are evolved, but a white powder remains insoluble. Presence of Sn or Sb. If no other metals are present, a fresh portion may be dissolved in H Cl , and the solution examined by H_2S , and by Hg Cl_2 , for Sb and Sn. If other metals are present, collect the white insoluble oxides and fuse with Hydrate of Soda in a silver crucible; treat the cooled mass with water, and add one-third of its volume of Alcohol; filter.
- | | |
|--|---|
| Acidulate the filtrate with H Cl , and examine the solution for Sn, and for As which may have accompanied it. | Dissolve the residue of Sodium Antimonate in H Cl and examine the solution for Sb. |
|--|---|
4. If the metal is unchanged by H NO_3 , boil with H Cl . Al dissolves readily. (Sn or Sb are dissolved by prolonged boiling with H Cl .)
 5. If a metal still remains unchanged, dissolve in Nitro-hydrochloric Acid (Aqua Regia), and test for Au by Fe SO_4 , or Sn Cl_2 , and for Pt, by NH_4Cl .

TABLE FOR THE SEPARATION OF METALS INTO GROUPS.

To the greater portion of the solution, add H Cl in excess.

Dilute the filtrate with water; saturate it with H_2S , and heat gently.						
<p>The ppt. may contain $Pb\ Cl_2$ white. $Ag\ Cl$ white. $Hg_2\ Cl_2$ white.*</p> <p>Group I.</p>	<p>Evaporate the filtrate to dryness. If organic matter is present, heat the residue to redness, but not otherwise. Add a little conc. $H\ Cl$ and $H\ NO_3$, then dilute with water, and heat until only a white residue of Silica remains;† add $NH_4\ Cl$ (if necessary,) and $NH_4\ HO$; heat gently, and filter.</p>					
<p>The ppt. may contain Insoluble in alkalis { $Pb\ S$ black. $Hg\ S$ black. $Cu\ S$ black. $Bi_2\ S_3$ black. $Cd\ S$ yellow. Sulphides { $Sn\ S$ brown. $Sb_2\ S_3$ yellow. $Sb_2\ S_5$ } Orange. $As_2\ S_3$ yellow. $Au_2\ S_3$ black. $Pt\ S_2$ black. Soluble in alkalis</p> <p>Group II.</p>	<p>To the filtrate add slight excess of $(NH_4)_2\ S$, or pass $H_2\ S$ gas through the solution, and filter.</p> <table><tr><td><p>Ppt. may contain $Al\ H_2\ O_3$ white. $Fe\ H_2\ O_3$ red. $Cr\ H_2\ O_3$ green. $Al\ P\ O_4$ white. and Phosphates of the Alkaline Earths, white.</p><p>Group III.</p></td><td><p>Ppt. may contain $Ni\ S$ black. $Co\ S$ black. $Zn\ S$ white. $Mn\ S$ flesh-coloured.</p><p>Group IV.</p></td><td><p>To filtrate add $NH_4\ Cl$, if necessary, and $(NH_4)_2\ CO_3$; filter.</p><table><tr><td><p>Ppt. may contain $Ba\ CO_3$ $Sr\ CO_3$ $Ca\ CO_3$</p><p>Group V.</p></td><td><p>The filtrate may contain salts of Mg. Li. K. Na. NH_4</p><p>Group VI.</p></td></tr></table></td></tr></table>	<p>Ppt. may contain $Al\ H_2\ O_3$ white. $Fe\ H_2\ O_3$ red. $Cr\ H_2\ O_3$ green. $Al\ P\ O_4$ white. and Phosphates of the Alkaline Earths, white.</p> <p>Group III.</p>	<p>Ppt. may contain $Ni\ S$ black. $Co\ S$ black. $Zn\ S$ white. $Mn\ S$ flesh-coloured.</p> <p>Group IV.</p>	<p>To filtrate add $NH_4\ Cl$, if necessary, and $(NH_4)_2\ CO_3$; filter.</p> <table><tr><td><p>Ppt. may contain $Ba\ CO_3$ $Sr\ CO_3$ $Ca\ CO_3$</p><p>Group V.</p></td><td><p>The filtrate may contain salts of Mg. Li. K. Na. NH_4</p><p>Group VI.</p></td></tr></table>	<p>Ppt. may contain $Ba\ CO_3$ $Sr\ CO_3$ $Ca\ CO_3$</p> <p>Group V.</p>	<p>The filtrate may contain salts of Mg. Li. K. Na. NH_4</p> <p>Group VI.</p>
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* Silicic, Boric, Benzoic and Uric Acids may also be precipitated by Hydrochloric Acid.

† The solution should be tested by means of (Potassium Ferrocyanide) K₄ Cyf, for Ferric Salts, and by (Potassium Ferricyanide) K₃ Cyf, for Ferrous Salts; if the latter are present, the solution must be boiled with gradual addition of H N O₃, until the Ferrous have been completely converted into Ferric Salts.

GROUP I.

*The ppt. may contain Pb Cl₂, Ag Cl, (Hg₂) Cl₂.**

Boil the ppt. in a large test-tube, with a large quantity of water, till free from Pb Cl ₂ .		
The filtrate may contain Pb Cl ₂ .	The white residue may contain Ag Cl, Hg ₂ Cl ₂ . Add excess of N H ₄ H O.	
	<p>Solution may contain $\left. \begin{matrix} H_2 \\ Ag \end{matrix} \right\} N Cl$.</p> <p>Confirm by adding H N O₃ to the Ammoniacal solution till the liquid shows an acid reaction. A white curdy ppt. of Ag Cl, shows the presence of Ag.</p>	<p>Residue is now black and consists of $\left. \begin{matrix} H_2 \\ Hg_2 \end{matrix} \right\} N_2 Cl_2$.</p> <p>Confirm.</p> <p>Dry some of the black residue and mix with dry N₂ O₅, and heat in a bulb tube.</p> <p>A metallic mirror or globules indicate Hg₂ as MERCURIOSUM.</p>
Confirm by adding a few drops of H ₂ S O ₄ , white ppt.		

* Unless H Cl has been added in excess, and the solution gently heated, certain Oxychlorides of Bi and Sb, Sn, also H₂ Si O₃ and some other substances may have been precipitated in this Group.

GROUP II.

The ppt. may contain Pb S, Hg S, Cu S, Bi₂ S₃, Cd S, Sn S₂, Sn S, Sb₂ S₃, Sb₂ S₅, As₂ S₃. Au and Pt must be specially tested for in a separate portion of the filtrate from Group I. Wash well, until the filtrate is free from H Cl. Transfer to a flask and boil with (N H₄) S or K H O, and filter.

Residue may consist of Pb S, Hg S, Bi ₂ S ₃ , Cu S, Cd S. Wash well, and boil in conc. Nitric Acid until all action ceases, add dilute H ₂ S O ₄ as long as a ppt. falls; allow to stand, and then filter (addition of alcohol alone ensures the complete precipitation of lead).		Add to the filtrate H Cl, and H ₂ S, yellow ppt. Agitate with N H ₄ H C O ₃ in the cold for ten minutes, and filter.	
Residue of Hg S, black, Pb S O ₄ white, and S.	Solution may contain Bi ₂ O ₃ , Cu O, Cd O. Add excess of Ammonia; boil and filter.	Filtrate may contain As ₂ S ₃ , add H Cl. A yellow ppt. indicates As. Dry and test by reduction with Na ₂ CO ₃ and K Cy in a bulb-tube.	Residue many contain Sn and Sb as sulphides: dissolve in <i>as small a quantity as possible of aqua regia</i> , and pour the solution into a small Hydrogen apparatus containing pure zinc, and dilute H ₂ SO ₄ .*
Boil in Tartaric Acid and add Ammonia in excess, boil; allow to cool; filter.	Ppt may be Bi ₂ O ₃ . Dissolve in H Cl. Evaporate just to dryness, and add water; a cloud or milkiness indicates Bi.	Metallic mirror of ARSENIC.	Sb H ₂ gas comes off: burn the gas and collect the metal on a zinc. Detach a porcelain plate; add K Cl O to the stains, no change indicates
Residue, confirm by reduction with Na ₂ CO ₃ in a bulb tube. Globules of Hg as MERCURICUM	To Solution, add Acetic Acid and then K ₂ Cr O ₄ yellow ppt. indicates Pb.		TIN, if present, will be precipitated on the zinc. Detach a portion; dissolve in H Cl, and test by means of Hg Cl ₂ , and by the blow-pipe.
			Sa.
		* Or the Hydrochloric solution may be placed in a platinum dish; if a rod of zinc be then introduced into the liquid, so as to touch the platinum outside the liquid only, a brown film of metallic ANTIMONY will rapidly adhere closely to the platinum, while TIN will be reduced in the form of a fine powder.	

GROUP III.

NOTE. It is well to test a small portion of the ppt. for Phosphates by Ammonium Nitro-Molybdate; if no yellow ppt. falls on heating, all that portion of the manipulation which refers to the separation of Phosphates may be omitted in this table.

The ppt. may contain Al, Cr, Fe and Phosphates; wash well, until no trace of Ammonia remains; then dissolve in as small a quantity as possible of H Cl.; add K H O in excess, and filter.

Filtrate may contain $\text{Al H}_3 \text{O}_3$, $\text{Cr H}_3 \text{O}_3$ and Al PO_4 . Boil for some time, and filter.		Ppt. may contain $\text{Fe H}_3 \text{O}_3$ and Phosphates. Digest with Acetic Acid.	
Ppt. Green is $\text{Cr}_2 \text{O}_3$. Confirm by fusion with KNO_3 , and $\text{Na}_2 \text{CO}_3$ on Platinum foil. A yellow mass indicates Cr.	Filtrate may contain $\text{Al H}_3 \text{O}_3$ and Al PO_4 . Add Acetic Acid in slight excess.	Residue is reddish white Fe PO_4 .	To the Solution add Citric Acid and excess of Ammonia; filter, if necessary. A white ppt. indicates an ALKALINE-EARTHY PHOSPHATE. Dissolve in H Cl ; add Potassium Acetate and $\text{Fe}_3 \text{Cl}_6$ until the liquid becomes distinctly red; boil until it has lost its red colour; filter, and examine the filtrate for Alkaline earths.* * See Groups V. & VI.
	Ppt. is Al PO_4 . To filtrate add Ammonia. A white Ppt. is $\text{Al H}_3 \text{O}_3$.		
		Add to filtrate H Cl and $\text{K}_4 \text{Cfy}$. A blue Ppt. indicates Iron otherwise than as Phosphate. (Ferrium and Ferrosium must be distinguished in the original solution.)	

GROUP IV.

Boil the Precipitate of Sulphides as quickly as possible with Acetic Acid, and filter.

<p><i>In solution</i> Manganese Acetate.</p> <p>Evaporate to dryness, and fuse on Platinum foil with KNO_3 and Na_2CO_3; a green mass indicates</p> <p>Mn.</p>	<p>Residue, if white, is ZnS; if black, it may also contain NiS, CoS. Dissolve in the least possible quantity of HNO_3; add KHO in excess, and filter.</p>	
<p><i>In solution</i> OXIDE OF ZINC.</p> <p>Pass a current of H_2S through the solution. A white ppt. indicates</p> <p>Zn.</p> <p>Confirm by Bp. test with $Co(NH_3)_6$.</p> <p>See preliminary examination.</p>		<p>Dissolve the <i>Precipitate</i> in HCl; add solution of K_2CrO_4 in excess, and boil with more HCl as long as H_2 is evolved; add KHO in excess, and filter</p>
<p>Ppt. may contain NICKEL. Confirm by Borax bead.</p>		<p>Evaporate the filtrate to dryness, and test for COBALT by Borax bead.</p>

GROUP V.

The white ppt. may consist of Barium, Strontium, and Calcium, as Carbonates. Dissolve off the filter in the smallest possible quantity of Hydrochloric acid, and dilute largely with water ; divide into three portions.

I.	II.	III.
<p>Add (Calcium Sulphate) Ca SO_4 or very dilute $\text{H}_2 \text{SO}_4$. An immediate ppt. indicates</p> <p style="text-align: center;">BA.</p> <p>Ppt. after some time indicates</p> <p style="text-align: center;">SR.</p>	<p>If Ba or Sr are present, add dilute $\text{H}_2 \text{SO}_4$ and filter ; if these are absent omit the addition of $\text{H}_2 \text{SO}_4$; neutralise the solution with $\text{NH}_4 \text{HO}$, and add (Ammonium Oxalate) $(\text{NH}_4)_2 \text{C}_2 \text{O}_4$.</p> <p>An immediate white ppt. indicates</p> <p style="text-align: center;">CA.</p>	<p>Examine by flame of Bunsen's burner, either with or without the aid of a Spectroscope.</p> <p style="text-align: center;">A Green flame indicates BA. A Crimson " " SR. A Red " " CA.</p>

GROUP VI.

The Solution may contain Magnesium and the Alkaline metals.

<p>To a small portion add $\text{NH}_4\text{H O}$ and $\text{Na}_2\text{H P O}_4$. A white crystalline ppt. indicates Mg.</p>	<p>Evaporate a larger portion to dryness, and ignite until fumes of Ammoniacal Salts cease to be evolved.* Dissolve a portion of the residue in water, decant the clear solution into a watch glass, and add H Cl and Pt Cl_4. A Yellow crystalline ppt. indicates K. Examine a portion in the flame of Bunsen's burner. A Yellow flame indicates Na. A Violet " " K. A Crimson " " Li.</p>	<p>Test for $\text{N H}_4\text{H O}$ in a fresh portion of the original solution by heating it with Ca O or K H O. The odour, or the power of changing red litmus paper blue, when held over the mouth of the tube, indicates N H_4.</p>
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* If Lithium is to be looked for, the residue after ignition must be digested with a mixture of absolute Ether and Alcohol. The solution will burn with a crimson flame if Li. is present.

EXAMINATION FOR MINERAL ACIDS.

The presence of bases often interferes with the detection of acids; in such cases, the bases may be removed by boiling the substance with the least possible excess of (Sodium Carbonate) Na_2CO_3 , and filtering. The solution must be carefully neutralised by the addition of Nitric Acid, drop by drop.

Nitric and Carbonic Acids must be looked for in the original substance.

- I. Having prepared a clear solution, add (Barium Chloride) Ba Cl_2 , or (Barium Nitrate) $\text{Ba}(\text{NO}_3)_2$.

The following Acids will be precipitated from a neutral solution.

SULPHURIC, white, insoluble in H NO_3 .

CARBONIC, white, soluble in H NO_3 , with effervescence.

BORIC, white, soluble in H NO_3 .

PHOSPHORIC, white, soluble in H NO_3 .

SILICIC, white, " "

HYDROFLUORIC, white, " "

CHROMIC, yellow, " "

- II. Add (Silver Nitrate) Ag NO_3 . The following Acids are precipitated from neutral solutions.

The ppts. insoluble in H NO_3 .

HYDROCHLORIC, white.

(Soluble in Ammonia.)

HYDROBROMIC, yellowish-white.

(Slightly soluble in Ammonia.)

HYDRIODIC, pale yellow.

(Insoluble in Ammonia.)

HYDROSULPHURIC, black.

The ppts. soluble in H NO_3 .

CARBONIC, white, soluble in acids with effervescence.

BORIC, white.

PHOSPHORIC, yellow.

META-PHOSPHORIC, white.

SILICIC, white.

CHROMIC, red

N. B. — Free Sulphurous, and Hyposulphurous Acids, and Ferrous Salts produce black precipitates of reduced silver when heated with Ag NO_3 .

- III. The following acids and their salts are not precipitated by any re-agent; but they decolourise a solution of Indigo when heated with it, after the addition of pure H_2SO_4 .

(NOTE. — Nitrous, Chlorous, and Hypochlorous Acids also decolourise Indigo; but they are pptd. by Ag NO_3 .)

NITRIC, CHLORIC.

[BROMIC, IODIC.]

SPECIAL TESTS FOR MINERAL ACIDS.

Salts of SULPHUR ACIDS are detected by fusion with Na_2CO_3 on charcoal, in the inner blow-pipe flame; if the mass is placed on a bright surface of Silver, and moistened, a black stain will be produced; or, if the mass is acidulated, H_2S will be evolved.

SULPHURIC Acid is sufficiently indicated by BaCl_2 and HNO_3 .

SULPHUROUS and HYPOSULPHUROUS are indicated by the preliminary examination, and by their behaviour with AgNO_3 .

CARBONIC and HYDROSULPHURIC are detected by the preliminary examination.

BORIC. Acidulate with H_2SO_4 , and dissolve in Alcohol. When the Alcohol is now burnt, Boric Acid imparts a green tinge to the edge of the flame.

PHOSPHORIC gives a yellow ppt. with Ammonium Nitro-molybdate; and a white crystalline ppt. with a mixture of NH_4Cl , MgSO_4 and NH_4HO .

HYDROFLUORIC. Heated with H_2SO_4 conc.; the fumes of HF etch glass.

CHROMIC is reduced to Chromic Oxide by boiling with HCl and Alcohol, or SO_2 .

SILICIC is detected in the examination for bases.

HYDROBROMIC. 1.— H_2SO_4 liberates Bromine; red liquid or fumes. 2.—Add Starch paste, then Chlorine water drop by drop; yellow colour indicates Br .

HYDRIODIC. 1.— H_2SO_4 liberates Iodine, which may be recognised by its colour and odour. 2.—Mix with Starch paste, and add Chlorine water cautiously; a deep blue colour indicates I .

NITRIC. Add a crystal of FeSO_4 , then pure H_2SO_4 , and allow to stand; a dark brown haze over the crystal indicates Nitric or Nitrous Acid.

NITROUS. When mixed with Starch paste and KI , the blue Iodide of Starch is produced as soon as Nitrous Acid is set free by the addition of a drop of pure H_2SO_4 .

CHLORIC. 1.—When freed from Chlorides by AgNO_3 , the Chlorates may be converted into Chlorides by fusion; and then the white curdy ppt. will be formed by addition of AgNO_3 .

2.—The odour of the gas set free by addition of H_2SO_4 is also characteristic.

HYPOCHLOROUS. Even the Alkaline Salts bleach Indigo. The odour is also characteristic.

EXAMINATION OF ORGANIC COMPOUNDS.

Non-volatile Organic substances are either charred when heated in an open glass tube, or with Sulphuric Acid in a test tube, or they evolve Carbonic gas which renders lime-water turbid.

Volatile Organic substances give characteristic odours when thus heated.

Alkaloids and other Nitrogenous Organic substances yield Ammonia when mixed with fused KH_2O , or with soda-lime and strongly heated. (If Ammonia is evolved while yet cold, it probably comes from an Ammonium Salt.)

ACIDS.

I. Heat a portion of the substance in an open tube.

Immediately blackened :

TARTARIC, with odour of burnt sugar.

URIC, with odour of burnt feathers.

HIPPURIC, with odour like Oil of Bitter Almonds.

GALLIC.

TANNIC.

ETC.

Fuses and becomes black after some time :

CITRIC, $H_3C_6H_5O_7$; pungent odour.

Not blackened. White sublimate :

OXALIC.

Yields white sublimate and charred residue :

MALIC, MECONIC, PYROGALLIC.

Not blackened ; volatile ; emit characteristic odour :

Acetous odour . . . ACETIC, FORMIC.

Aromatic " . . . BENZOIC.

Irritating " . . . SUCCINIC.

Butter " . . . BUTYRIC, VALERIC, and others.

Tar " . . . PHENIC.

Peculiar " . . . HYDROCYANIC, &c.

Acetates give odour of Acetone.

II. Heat a portion of the substance in a test tube with Conc. H_2SO_4 .

Immediately blackened :

TARTARIC, PYROGALLIC, GALLIC, TANNIC, HIPPURIC.

Blackened after some time :

CITRIC, MALIC, URIC, MECONIC.

Not blackened ;

- Evolves CO_2 , and CO which burns with a blue flame OXALIC.
 Evolves CSO , which burns with blue flame and gives odour of S O_2 SULPHOCYANIC.
 Evolves CO and NH_3 HYDROCYANIC and other CYANOGEN ACIDS.

Volatile :

- ACETIC, FORMIC, BENZOIC, SUCCINIC evolves pure CO.
 Heated with moderately dilute H SO_4 , the Cyanogen compounds evolve Hydrocyanic Acid (peculiar odour).

III. If the solution is alkaline or neutral, add H Cl.

- URIC is precipitated as a white powder.
 BENZOIC " white flakes.
 HIPPURIC " white feathers, insoluble in Ether, soluble in *boiling* water.

IV. To a neutral solution add Ag NO_3 . The following acids are precipitated.

- HYDROCYANIC. White curdy ppt.; insoluble in H NO_3 , soluble in Ammonia, and in Alkaline Cyanides.
 SULPHOCYANIC. White; soluble in Ammonia.
 FERRO- and FERRI-CYANIC. White; soluble in Ammonia
 MECONIC. White; soluble in Ammonia.
 OXALIC " " "
 SUCCINIC " " "
 BENZOIC " " "
 TARTARIC. White; soluble in acids and in Ammonia; silver mirror reduced on boiling.
 CITRIC. White; soluble in acids and in Ammonia.
 MALIC " " "
 ACETIC " " "
 FORMIC and PYROGALLIC reduce metallic silver.

V. To a neutral solution add (Calcium Chloride) Ca Cl_2 ; shake and filter.

To ppt., add Acetic Acid.		To filtrate, add a little lime-water, and boil. A ppt. indicates	
A portion remaining undissolved in Acetic, but soluble in H Cl, indicates OXALIC.	Dissolved;	CITRIC.	
	TARTARIC.	Filter and boil for a long time, with addition of Alcohol. A ppt. indicates MALIC.	

VI. Add Fe_2Cl_6 .

The following give a red colour, but no ppt.

ACETIC, discharged by H Cl .

FORMIC, " " "

PYROGALLIC, " " (blue with Fe SO_4).

SULPHOCYANIC, discharged by Hg Cl_2 (Mercuric Chloride), but not by H Cl .

MECONIC, not discharged by Hg Cl_2 , nor by H Cl .

The following give reactions.

CARBOLIC or PHENIC, purple solution.

GALLIC and TANNIC give deep black solutions.

BENZOIC, SUCCINIC, and HIPPURIC give light red ppts.

FERROCYANIC gives Prussian blue in acid solutions.

FERRICYANIC gives only a brown or green colour; but with Ferrous Salts it gives a deep blue ppt.

VII. Add K HO .

TARTARIC gives white crystalline ppt. with acid solutions, or after addition of Acetic.

GALLIC gives green, then red and brown, colour.

TANNIC gives brown.

PYROGALLIC gives deep brown or black.

SPECIAL TESTS.

URIC ACID. To the dry insoluble powder add a drop of Nitric Acid, and evaporate to dryness by a gentle heat; a red stain appears. When cold, add Ammonia; a purple solution of Murexide is produced.

TANNIC ACID precipitates a solution of gelatine.

SUCCINIC ACID. To a solution add NH_4HO , and Ba Cl_2 ; no ppt. Then add Alcohol; white ppt.

HYDROCYANIC ACID. 1.—Add Fe SO_4 , and Fe_2Cl_6 . If the solution was Alkaline, the mixed Oxides of Iron only will be precipitated; but on addition of H Cl , a Prussian blue precipitate will be formed. 2.—Add a few drops of yellow Ammonium Sulphide, and evaporate to dryness. Dissolve in water, and add Fe_2Cl_6 ; a blood red solution is produced.

**BEHAVIOUR OF SOME NEUTRAL SUBSTANCES WHOSE PRESENCE MAY BE
SUSPECTED BY THEIR TASTE.**

	Heated in a Test Tube.	Heated with H_2SO_4	Heated with $KH O$.	Heated with Potassic solution of Copper Tartrate.
ALCOHOL	Volatile without blackening; vapour has odour, and is very combustible.	Does not blacken. (Methylated Spirit becomes brown.)	Behaves as when heated alone. (Methylated Spirit becomes brown.)	
GLYCERINE.	Decomposes without blackening, and emits acrid fumes.	Emits acrid fumes.	Behaves as when heated alone.	
CANNOSE. (Cane Sugar.)	Chars, and gives odour of Caramel.	Chars rapidly.	Unaltered.	Does not give Precipitate of $Cu_2 O$.
GLUCOSE. (Grape Sugar.)	Chars.	Chars slowly.	Becomes dark brown.	Gives a red Precipitate of $Cu_2 O$.
LACTOSE. (Sugar of Milk.)	<i>Differs from the other Sugars in being insoluble in Alcohol.</i> Chars.	Chars slowly.	Gives brown solution slowly.	Gives a red Precipitate of $Cu_2 O$.
MANNITE.	Chars.	Dark solution.	Dark solution.	Does not give a red Precipitate of $Cu_2 O$.

GUM softens in cold water; gives no reaction with Tincture of Iodine; and is precipitated by tribasic Lead acetate.

STARCH consists of microscopic rounded grains, which polarise light; is insoluble in cold water, but forms a paste when boiled; and forms a deep blue compound with Tincture of Iodine.

Dextrin resembles starch in appearance, but softens like gum in cold water, and generally has an odour of rushes. Pure Dextrine does not give a blue compound with Iodine; but the commercial article (British Gum) does; is not precipitated by tribasic Lead acetate.

TABLE FOR THE SEPARATION OF ORGANIC BASES.

To a solution of the substance in water or dilute acid add KHO , drop by drop, till the liquid has only a slightly Alkaline reaction.

1. If oily drops are separated, which have an odour of ANILINE; like that of mice, CONINE; or of Tobacco, NICOTINE, these volatile liquid alkaloids may be separated by distillation in a small retort and receiver; the characteristic tests may then be applied. They are also soluble in Ether, and their Oxalates are soluble in Alcohol.
2. If the liquid gives no odour in the cold, but evolves Ammonia on boiling, UREA is probably present. If it gives the fishy odour of Methylamine, CAFFEINE may be present. Dissolve the original substance, rendered alkaline by KHO , in Alcohol, filter and evaporate the filtrate to dryness, and apply special tests.
3. If KHO gives no reaction, test the original substance for SALICINE.
4. A white ppt. may be MORPHINE, QUININE, CINCHONINE, NARCOTINE, CODEINE, STRYCHNINE, BRUCINE, VERATRINE. Add KHO in excess, and filter. To the filtrate add CO_2 or NaHCO_3 , evaporate to dryness, and dissolve in water; any residue which now remains insoluble must be tested for Morphine.

Dissolve the precipitate insoluble in excess of KHO (or, if nothing has yet been discovered, dissolve the original substance) by dilute H_2SO_4 in slight excess, and add solution of NaHCO_3 until the acid reaction is neutralised, and allow to stand—

The ppt. may contain
NARCOTINE,
QUININE,
CINCHONINE.

A.

Evaporate the solution to dryness, and dissolve in cold water; any residue insoluble in water may be CODEINE, STRYCHNINE, BRUCINE, VERATRINE, and trace of QUININE. B.

A. Separation of Narcotine, Cinchonine, and Quinine.

Dissolve the alkaloids in HCl , add Ammonia in excess, and shake up the ppt. with Ether; decant the ethereal solution.

Test the residue for
CINCHONINE.

Evaporate the ethereal solution; dissolve in HCl , dilute with 200 parts of water, neutralise the solution with NaHCO_3 , and allow the liquid to stand for some time; a ppt. indicates NARCOTINE: filter.

To the ppt. apply
special tests for
NARCOTINE.

Test the filtrate for
QUININE.

B. *Separation of Strychnine, Brucine, Veratrine, (Codeine).*

Dry the precipitated alkaloids on the water bath; digest with absolute Alcohol, and filter.

The residue is

STRYCHNINE.

Wash with absolute Alcohol, dissolve in Chloroform, divide the solution into several portions, evaporate these to dryness on porcelain dishes and apply the colour tests for

STRYCHNINE.

Evaporate the Alcoholic solution to dryness on a water bath, and if Codeine has to be separated, digest in Ammonia; decant and evaporate the clear solution, and test it for CODEINE; then test separate portions of the residue for BRUCINE and for VERATRINE; and, if necessary, for QUININE, of which a minute quantity may be present in this residue.

CHARACTERISTIC TESTS FOR THE PRINCIPAL ORGANIC BASES.

I. Volatile bases; oily liquids.

ANILINE, C_6H_7N . 1.—Has a peculiar odour; is tinged brown by exposure, and stains deal yellow.

2.—With Chloride of Lime, produces a purple colour.

3.—Heated with $HgCl_2$ crystals, produces a purple mass, soluble in Alcohol, giving a magenta solution.

4.—A Sulphuric Acid solution, with Oxygen evolved at positive electrode of an electrolytic cell is tinged blue, changing to violet and red.

CONINE, $C_8H_{15}N$. 1.—Has the odour of mice.

2.—With HNO_3 , gives a blood-red colour.

3.—With H_2SO_4 , gives purple, then olive colour.

4.—Is pptd. by $AuCl_3$, but not by $PtCl_4$.

5.—Coagulates a solution of Albumen.

NICOTINE, $C_{10}H_{14}N_2$. 1.—Has an odour of tobacco, and is tinged brown by exposure.

2.—Is pptd. both by $AuCl_3$ and by $PtCl_4$.

3.—Does not coagulate solution of Albumen.

II. Non-volatile Bases — of vegetable origin.

MORPHINE, $C_{17}H_{19}NO_3$. 1.—Crystallises in four-sided prisms; soluble in water and Alcohol, but not in Ether.

2.—With Fe_2Cl_6 neutral, is tinged blue.

3.—With HNO_3 conc., is tinged red.

4.—Heated with H_2SO_4 , a colourless solution, changed when cold to violet by H_2SO_4 containing HNO_3 ; and further, to mahogany colour by $K_2Cr_2O_7$.

CODEINE, $C_{18}H_{21}NO_3$, resembles Morphine in its physiological action, but does not answer to its characteristic tests.

1.—It is more soluble in water, Ether and Ammonia, than Morphine, but is insoluble in Potash.

2.—With HNO_3 is tinged yellow.

QUININE, $C_{20}H_{24}N_2O_2$. 1.—Crystallises in tufts of silky needles, sparingly soluble in water, freely in Alcohol; soluble in Ether, &c.

2.—Solutions of its salts are fluorescent if no Hydracid is present.

3.—Heated in a tube gives a violet-red sublimate, and odour of Quinoline.

4.—With Chlorine water, then Ammonia, is tinged bright green.

5.—With Chlorine water, then K_4Cfy , then Ammonia, is tinged deep red.

CINCHONINE, $C_{20}H_{24}N_2O$. 1.—Crystallises in four-sided prismatic needles, very slightly soluble in water; soluble in Alcohol; insoluble in Ether.

2.—Heated in a tube gives a violet-red sublimate, and odour of Quinoline.

3.—With Chlorine water, then Ammonia, gives a yellowish-white precipitate.

NARCOTINE, $C_{23}H_{28}NO_7$. 1.—Crystallises in rhombic prisms, insoluble in water; slightly soluble in Alcohol and Ether.

2.—With Chlorine water, then Ammonia, gives a yellowish-red liquid.

3.—With pure H_2SO_4 , and heated, gives a reddish colour; and with H_2SO_4 , containing a trace of HNO_3 , gives a red colour.

4.—With dilute H_2SO_4 , then MnO_2 , gives, when boiled and cooled, crystals of Opianic Acid.

STRYCHNINE, $C_{21}H_{23}N_2O_2$. 1.—Crystallises in rhombic prisms; very slightly soluble in water and ordinary Alcohol, yet the solutions are intensely bitter; insoluble in absolute Alcohol and in Ether. The best solvents are Chloroform and amylic Alcohol.

2.—The dry alkaloid, dissolved in a drop of pure strong H_2SO_4 , gives a play of colours from purple-violet to red, with any of the following oxidizers, if cold:— $K_2Cr_2O_7$, K_2Cfdy , MnO_2 , PbO_2 , Oxygen at the positive electrode of an electrolytic cell.

BRUCINE, $C_{28}H_{26}N_2O_4$. 1.—Crystallises in stars of prismatic needles, soluble in water and Alcohol, but not in Ether.

2.—With HNO_3 conc., is tinged bright red; when heated, yellow, which is further changed to violet by $SnCl_2$, or by $(NH_4)_2S$.

3.—With Chlorine water, is tinged red, which Ammonia changes to yellow.

VERATRINE, $C_{28}H_{52}N_2O_8$. 1.—Crystallises in small prisms; insoluble in water, soluble in Alcohol and Ether.

2.—It has an acrid burning taste, and causes violent sneezing when it reaches the membranes of the nose.

3.—With heat, or with HNO_3 , forms resinous masses.

4.—With H_2SO_4 , forms resinous masses, slowly becoming a red fluid.

5.—With Chlorine water is tinged brown, changing to faint brown with Ammonia.

CAFFEINE, THEINE, $C_8H_{10}N_4O_2$. 1.—Crystallises in silky needles; soluble in water, Alcohol, and Ether.

2.—May be sublimed unchanged, but when boiled with KHO solution is decomposed, evolving the fishy odour of Methylamine.

3.—With HNO_3 , evaporated to dryness, gives a red stain, changed to purple by cooling and adding Ammonia.

SALICIN, $C_{13}H_{18}O_7$ is not a base, but resembles Quinine.

1.—Crystallises in silky needles and scales, soluble in water and Alcohol, insoluble in Ether.

2.—With H_2SO_4 conc., gives a red resinous mass.

3.—Its solution, boiled with HCl , yields granular crystals, while sugar remains in the solution.

III. Base of animal origin.

UREA, CH_4N_2O . 1.—Crystallises in prisms; very soluble in water and Alcohol, insoluble in Ether.

2.—Heated, evolves Ammonia, &c., and yields a sublimate.

3.—Heated with KHO , or Na_2CO_3 , evolves Ammonia.

4.—A strong solution, with HNO_3 , deposits crystalline plates.

5.—A strong solution, with Oxalic Acid, deposits tabular prisms.

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